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**ATTN: Document Control Desk**
John H. (Jack Sulima), Project Manager
Project Management Branch B
Division of High-Level Waste Repository Safety
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
EBB-2B2
11545 Rockville Pike
Rockville, MD 20852-2738

YUCCA MOUNTAIN - REQUEST FOR ADDITIONAL INFORMATION- SAFETY EVALUATION REPORT, VOLUME 3 - POSTCLOSURE CHAPTER 2.2.1.3.2, MECHANICAL DISRUPTION OF ENGINEERED BARRIERS, 2ND SET - (DEPARTMENT OF ENERGY'S SAFETY ANALYSIS REPORT SECTION 2.3.4)

Reference: Ltr, Sulima to Williams, dtd 11/5/2009, "Yucca Mountain – Request for Additional Information – Safety Evaluation Report, Volume 3 – Postclosure Chapter 2.2.1.3.2, Mechanical Disruption of Engineered Barriers, 2nd Set – (Department of Energy's Safety Analysis Report Section 2.3.4)"

The purpose of this letter is to transmit the U.S. Department of Energy's (DOE) responses to four (4) of the eight (8) Request for Additional Information (RAI). The responses for RAI Numbers 1, 2, 3, and 8 are provided as enclosures to this letter. DOE expects to submit the remaining RAIs on or before December 18, 2009.

Most of the DOE references cited in the RAI responses have previously been provided with the License Application (LA) or LA Update. A DOE reference cited in the RAI response Number 1, which has not been previously provided to the Nuclear Regulatory Commission, is included with this submittal.

There is one commitment identified in the enclosed response to RAI Number 8. If you have any questions regarding this letter, please contact me at (202) 586-9620, or by email to jeff.williams@rw.doe.gov.

Jeffrey R. Williams, Supervisor
Licensing Interactions Branch
Regulatory Affairs Division
Office of Technical Management

OTM: CJM-0125

Enclosures (5):

1. Response to RAI Volume 3, Chapter 2.2.1.3.2, Set 2, Number 1
2. Response to RAI Volume 3, Chapter 2.2.1.3.2, Set 2, Number 2
3. Response to RAI Volume 3, Chapter 2.2.1.3.2, Set 2, Number 3
4. Response to RAI Volume 3, Chapter 2.2.1.3.2, Set 2, Number 8
5. BSC (Bechtel SAIC Company) 2003. *21-PWR Waste Package Side and End Impacts*. 000-00CDSU0-01000-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20030227.0067; ENG.20050829.0004.

cc w/encls:
J. C. Chen, NRC, Rockville, MD
J. R. Cuadrado, NRC, Rockville, MD
J. R. Davis, NRC, Rockville, MD
R. K. Johnson, NRC, Rockville, MD
A. S. Mohseni, NRC, Rockville, MD
N. K. Stablein, NRC, Rockville, MD
D. B. Spitzberg, NRC, Arlington, TX
J. D. Parrott, NRC, Las Vegas, NV
L. M. Willoughby, NRC, Las Vegas, NV
Jack Sulima, NRC, Rockville, MD
Christian Jacobs, NRC, Rockville, MD
Lola Gomez, NRC, Rockville, MD
W. C. Patrick, CNWRA, San Antonio, TX
Budhi Sagar, CNWRA, San Antonio, TX
Bob Brient, CNWRA, San Antonio, TX
Rod McCullum, NEI, Washington, DC
B. J. Garrick, NWTRB, Arlington, VA
Bruce Breslow, State of Nevada, Carson City, NV
Alan Kalt, Churchill County, Fallon, NV
Irene Navis, Clark County, Las Vegas, NV
Ed Mueller, Esmeralda County, Goldfield, NV
Ron Damele, Eureka County, Eureka, NV
Alisa Lembke, Inyo County, Independence, CA
Chuck Chapin, Lander County, Battle Mountain, NV
Connie Simkins, Lincoln County, Pioche, NV
Linda Mathias, Mineral County, Hawthorne, NV
Darrell Lacy, Nye County, Pahrump, NV
Jeff VanNeil, Nye County, Pahrump, NV
Joe Kennedy, Timbisha Shoshone Tribe, Death Valley, CA
Mike Simon, White Pine County, Ely, NV
K. W. Bell, California Energy Commission, Sacramento, CA
Barbara Byron, California Energy Commission, Sacramento, CA
Susan Durbin, California Attorney General's Office, Sacramento, CA
Charles Fitzpatrick, Egan, Fitzpatrick, Malsch, PLLC

**RAI Volume 3, Postclosure Chapter 2.2.1.3.2, Second Set, Number 1:**

Reconcile the assumption that the waste package pallet is intact in the kinematic analyses (SAR Section 2.3.4.5.2) with the information indicating that the stainless steel connector tubes lose structural integrity (SAR Section 2.3.4.1). Or, demonstrate that the intact waste package pallet assumption does not underestimate significantly the potential for waste package damage in the kinematic analyses.

Basis: Although the kinematic analyses use an intact waste package emplacement pallet, DOE concludes that the stainless steel connector tubes in the pallet lose their structural integrity (SAR Section 2.3.4.1). This loss of connector integrity could result in a range of pallet pedestal orientations, potential impact locations, and impact frequencies that exceed the range of parameters considered by DOE. Larger uncertainty in pedestal orientation has the potential to affect calculations of impact locations and time of impact, relative velocity of the impact bodies, relative angle of impact of the impacting bodies, and forces between the impacting bodies. Information presented in SAR 2.3.4.5.2 and 2.3.4.5.4 is insufficient to determine if such uncertainties in pedestal orientation, impact location, and frequency would affect significantly the characteristics of waste package damage calculated in kinematic analyses.

# 1. RESPONSE

The intact waste package pallet assumption does not underestimate the potential for waste package damage in the kinematic analyses. In fact, the assumption that the waste package pallet remains intact for kinematic analyses overestimates the potential for waste package damage during seismic events. The overestimate results from analyses that show that damage to waste packages from package-pallet collisions is dominated by waste package-to-intact pallet strikes.

Waste package damage is dominated by package-to-intact pallet collisions. The waste package damage area fraction is dominated by more frequent seismic events that feature lower peak ground velocity (PGV) levels, rather than from the few events at larger PGV levels. For example, the mean conditional damaged area for the transportation, aging, and disposal (TAD)-bearing waste package with a 17-mm-thick outer corrosion barrier (OCB) and degraded internals at the 4.07 m/s PGV level is 5.42 $m^2$, which is about a factor of 20 greater than the mean conditional damaged area at the 0.4 m/s PGV level, 0.289 $m^2$ (see SNL 2007a, Table 6-12, for the 90% residual stress threshold). On the other hand, seismic events with a PGV level near 4.07 m/s are about 10,000 times less frequent than seismic events with a PGV level near 0.4 m/s, based on the bounded hazard curve (SNL 2007a, Table 6-3). The smaller and more frequent seismic events, therefore, have much greater contributions to total damaged area on a probability-weighted basis than the large, infrequent seismic events. This observation is also true for the TAD-bearing waste package with degraded internals at the 100% and 105% residual stress thresholds (SNL 2007a, Table 6-12), and also for the codisposal waste package with a 17-mm-thick OCB and degraded internals (SNL 2007a, Table 6-27).

Even if the stainless steel connector tubes, which connect the pallet pedestals, were to lose structural integrity (due to corrosion), the waste packages and pallet pedestals have very little relative motion for the lower PGV seismic events. Thus, the damage predictions for these lower PGV level seismic events would remain unchanged. Were a larger PGV level seismic event to occur when the pallet pedestals were no longer connected by the stainless steel connector tubes, waste package-to-pallet impacts would be characterized by one of three cases: (1) the waste package impacts both pedestals, (2) one pedestal is reoriented on the invert such that the waste package impacts a pedestal at one end and the invert at the other end, or (3) both pedestals are reoriented on the invert (each is free to move independently of the other, and over time seismic events displace the waste package) such that the waste package ultimately would impact only the invert. For Case 1, the angles and locations of impact would be similar to kinematic analyses with intact pallets. For Case 2, the angles of impact for the kinematic analyses would also be similar because the drip shield moves synchronously with the invert (SNL 2007b, Section 5.1), thereby imposing a kinematic constraint on the upward motion of the waste package. The locations of impact would be more toward the end of the waste packages, as the waste package would tend to slide horizontally off the remaining pedestal and onto the invert. Tables 6-49 and 6-50 of *Mechanical Assessment of Degraded Waste Packages and Drip Shields Subject to Vibratory Ground Motion* (SNL 2007b) show that damaged areas are less for impacts near the ends of a waste package than for impacts in the middle of a waste package. For Case 3, where the waste package is only impacting the invert, the waste package suffers the smallest amount of damage, because the force of impacts is distributed over a much larger area. Hence, the damage from a waste package falling onto the invert is negligible compared to waste package-to-pallet impacts (BSC 2003, Tables 5 and 8; SNL 2007a, Table 6-13).

It follows that the assumption that the waste package pallet remains intact for kinematic analyses overestimates the potential for waste package damage during seismic events. Because the potential for damage is overestimated, this response demonstrates that the intact waste package pallet assumption does not underestimate the potential for waste package damage in the kinematic analyses.

## 2. COMMITMENTS TO NRC

None.

## 3. DESCRIPTION OF PROPOSED LA CHANGE

None.

## 4. REFERENCES

BSC (Bechtel SAIC Company) 2003. *21-PWR Waste Package Side and End Impacts*. 000-00C-DSU0-01000-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20030227.0067; ENG.20050829.0004.

SNL (Sandia National Laboratories) 2007a. *Seismic Consequence Abstraction*. MDL-WIS-PA-000003 REV 03 ERD 1. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070928.0011; LLR.20080414.0012.

SNL 2007b. *Mechanical Assessment of Degraded Waste Packages and Drip Shields Subject to Vibratory Ground Motion*. MDL-WIS-AC-000001 REV 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070917.0006.

**RAI Volume 3, Postclosure Chapter 2.2.1.3.2, Second Set, Number 2:**

> Describe the engineering parameters, such as stress or strain, that were used in the expert judgment process to determine the rupture probability for multiple impacts to waste packages.
>
> Basis: DOE relies on engineering judgment to determine if multiple impacts to the waste package result in tensile rupture (SAR 2.3.4.5.1.4.2). If the degree of deformation from a single impact is judged significant, a second impact of equal or greater magnitude is judged sufficient to cause tensile rupture. Although DOE describes incipient damage to the waste package in SAR 2.3.4.5.2.1.3.2, DOE does not describe the magnitude of stress or strain on the outer corrosion barrier, the impact velocities that caused this damage, or the threshold in which such damage occurs. Information in the SAR does not explain how variations in these or other indicators of damage have been considered in the expert judgment process, such that the uncertainty in waste package damage potential has been considered in the analyses.

## 1. RESPONSE

DOE has evaluated strain in the outer corrosion barrier (OCB) as a function of impact velocity, impact location, and impact angle during its analysis of rupture probability for waste package-to-pallet impacts. The data for this evaluation are presented in 20 tables in *Mechanical Assessment of Degraded Waste Packages and Drip Shields Subject to Vibratory Ground Motion* (SNL 2007, Tables 6-55 to 6-63 and Tables 6-83 to 6-93). The data in the tables provide the technical foundation for a quantitative evaluation of rupture probability based on a maximum effective strain limit. The results from this quantitative evaluation led to an alternate approach for defining rupture probability based on deformation of the OCB. The alternate approach is qualitative and involves engineering judgment, but is considered to provide an upper bound to the rupture probabilities, as explained below.

The quantitative approach to evaluating rupture probability as a function of a maximum effective strain limit considered the detailed stress/strain state in each modeled OCB shell element (SNL 2007, Figure 6-25 and Appendix A). The minimum effective tensile strain limit for Alloy 22, 0.285, was used as an initial screening criterion (SNL 2007, Sections 6.2.2 and A.2). If the effective strain is always below 0.285, then rupture does not occur (SNL 2007, Section 6.3.2.2.5). If the minimum effective strain limit is exceeded, an effective strain limit for each element was reevaluated as a function of the stress state in the element (uniaxial tension, biaxial tension, or compression). In all single package-to-pallet impacts over a wide range of conditions, rupture did not occur because the maximum effective strain was always below the stress-state-dependent effective strain limit, or because the stress state was compressive. Additional details are provided in the response to RAI 3.2.2.1.3.2-2-003 and in *Mechanical Assessment of Degraded Waste Packages and Drip Shields Subject to Vibratory Ground Motion* (SNL 2007, Section 6.3.2.2.5).

Since the quantitative approach to assessing rupture based on maximum effective strain did not predict rupture, a probability of rupture assessment was developed based on deformation in the OCB of the waste package and the potential for multiple waste package-to-pallet impacts in the kinematic analyses.

Equivalent data for waste package-to-waste package impacts are presented in nine tables (SNL 2007, Tables 6-26 to 6-31 and Tables 6-35 to 6-37). Package-to-package impacts were not considered during the rupture analysis because the waste package-to-pallet impacts cause much more severe deformation of the OCB (SNL 2007, Sections 6.3.2.2.6 and 6.3.2.2.7).

Figures 6-31 to 6-36 in *Mechanical Assessment of Degraded Waste Packages and Drip Shields Subject to Vibratory Ground Motion* (SNL 2007) show deformations of various waste packages with intact and degraded internals. The deformations are a function of the OCB thickness, the impact velocity (3, 5, 7, and 10 m/s), and the impact angle (±6 degrees), with the impacts occurring at the mid-length of the waste package. The impact angle and impact location were chosen to maximize deformation of the OCB, providing an approach that overestimates the potential for rupture. In order to provide perspective for the previous figures, Figure 6-37 in the mechanical assessment report (SNL 2007) shows a three-dimensional view of the deformation of a 17-mm-thick OCB of a transportation, aging, and disposal (TAD)-bearing waste package with degraded internals for an impact velocity of 10 m/s.

The probability of rupture assessment is based on deformation associated with multiple large impacts, where a “large” impact is one that results in significant deformation of the OCB. The deformation shapes in Figures 6-31 to 6-36 were examined to determine a deformed state that could be reasoned to cause rupture if a second large impact occurred. For the TAD-bearing and codisposal waste packages with intact internals, deformation is insignificant even at the largest impact velocities. Thus, waste packages with intact internals do not rupture.

For both OCB thicknesses of the TAD-bearing and codisposal waste packages with degraded internals, deformation at an impact velocity of 3 m/s is not estimated to be severe enough to lead to rupture after multiple impacts at that level (Figure 1). However, for both OCB thicknesses of the TAD-bearing and codisposal waste packages with degraded internals, deformation increases as impact velocity increases. Deformation caused by impacts of 10 m/s is judged highly likely to cause rupture for both waste package types, and both OCB thicknesses, from multiple impacts at that velocity (Figure 1).

The deformed shapes are similar for both waste package types and both OCB thicknesses when the impact velocity is 5 m/s (Figure 1). The OCB shell starts to bulge noticeably at both sides of the deformed section, and the shell starts to have a noticeable kink where the waste package deforms into the center of the pallet cradle. It is estimated that deformation from a 5 m/s impact is a reasonable lower bound such that another impact above 5 m/s could cause a rupture of the OCB.

For impacts of 7 m/s, the degree of certainty as to whether multiple impacts at that velocity would cause rupture varies with the waste package type and OCB thickness (Figure 1). Deformation of the TAD-bearing waste package with 17-mm-thick OCB is sufficient that multiple impacts are judged to cause rupture (probability of 1.0). However, the TAD-bearing waste package with 23-mm-thick OCB and the codisposal waste package with 23- and 17-mm-thick OCBs are estimated to have varying probabilities (that are less than 1.0) associated with how likely multiple impacts at a 7 m/s impact velocity are to cause rupture. The probabilities for the TAD-bearing waste package with 23-mm-thick OCB and the codisposal waste package with 17-mm-thick OCB are estimated at 0.75 (3-in-4 chance), and the probability for the codisposal waste package with 23-mm-thick OCB is estimated at 0.667 (2-in-3 chance). Figure 1 summarizes the probabilities of rupture from multiple impacts associated with the deformed shapes of the TAD-bearing and the codisposal waste package with degraded internals and with 23- and 17-mm-thick OCBs.

The mechanical assessment report (SNL 2007, Section 6.3.3.2) describes the process of determining the impact force values associated with 5 and 7 m/s impacts for both waste package types. The force at 5 m/s is the threshold force for a probability of rupture of 0.0 due to multiple impacts. Thus, forces larger than this threshold would have a probability that is greater than 0.0 for rupture due to multiple impacts. The force associated with 7 m/s is termed the "upper force peg point" and is used to interpolate (and extrapolate) probabilities between 0.0 (at 5 m/s) and an upper bound of 1.0. The force associated with 10 m/s was not used directly, but was always larger than the force associated with a probability of rupture of 1.0 due to multiple impacts. The process for determining the impact force values and the extrapolation beyond the 5 to 7 m/s range were used to estimate the value that would produce a multiple impact rupture probability of 1.0. The estimates were intended to minimize the force values that cause rupture and to thereby account for the uncertainty in judgment used to determine rupture probability. Table 1 shows the threshold forces, upper force peg points, forces associated with a multiple impact rupture probability of 1.0, and the forces for 10 m/s impact, for both waste package types.

Incipient rupture is defined as a state in which a waste package has been subjected to one impact during a seismic event that causes deformation such that another large impact is considered likely to cause rupture of the waste package. A waste package is in a state of incipient rupture at the end of a kinematic seismic analysis if one, and only one, impact occurs during that analysis and causes deformation such that another large impact during a later seismic event would cause rupture of the waste package (SNL 2007, p. 6-109). If two or more such impacts occur for a waste package during a single kinematic seismic analysis, then the waste package is in a state of rupture. The probabilities of the waste packages being in either of these states are computed by statistically combining the rupture probabilities during a kinematic seismic analysis for the individual impacts over the corresponding force thresholds.

The probability of rupture assessment overestimates the probability of rupture because of the following: (1) the force threshold is fairly low and was determined based on smaller (less severe and more frequent) deformations and impact angles of ±6 degrees (which generally have lower impact forces than impact angles of ±0.25 degrees at higher impact velocities (SNL 2007, Tables 6-11 to 6-14)); and (2) deformations shown in Figure 1 are overly large as the waste package was allowed to "wrap around" the pallet without contacting the invert. The presence of the invert would support the waste package as it wraps around the pallet, reducing the waste package-to-pallet impact force and deformation of the waste package.

Table 1. Impact Forces (lbs) and Probabilities of Rupture Due to Multiple Impacts for Various Waste Package Types and States

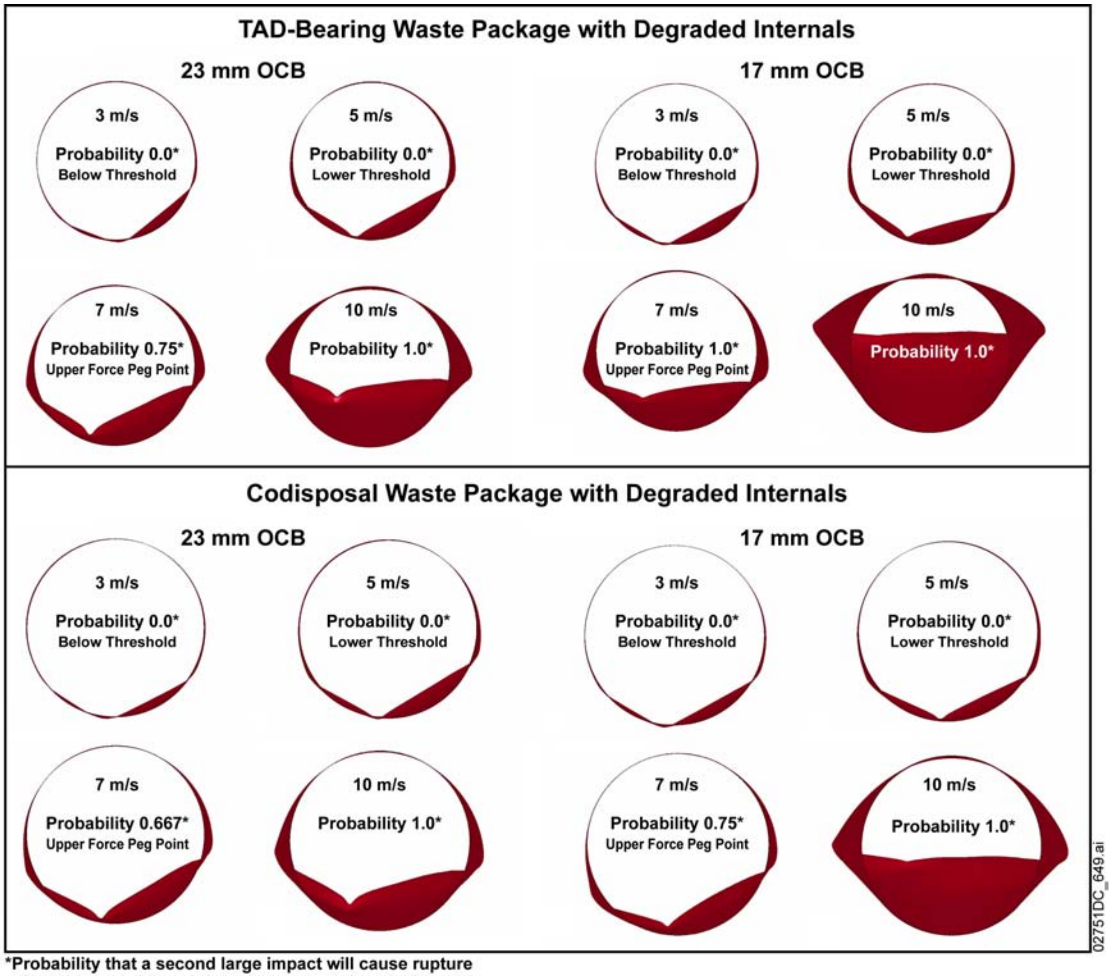
| Impact Velocity | Item | Waste Package with Degraded Internals | | | |
|---|---|---|---|---|---|
| | | TAD-bearing | | Codisposal | |
| | | 23-mm OCB | 17-mm OCB | 23-mm OCB | 17-mm OCB |
| 5 m/s | Threshold Force[1] (lbs) Probability of 0 | 6,000,000 | 6,000,000 | 5,800,000 | 5,800,000 |
| 7 m/s | Upper Force Peg Point[1] (lbs) | 7,800,000 | 7,800,000 | 7,100,000 | 7,100,000 |
| | Probability at Peg Point | 0.75 | 1 | 0.667 | 0.75 |
| NA | Force (lbs) at Probability of 1[2] | 8,400,000 | 7,800,000 | 7,750,000 | 7,530,000 |
| 10 m/s | Impact Force (lbs)[3] | 12,900,000 | 12,900,000 | 9,700,000 | 9,700,000 |

Sources: Data for 5 and 7 m/s impact velocities are from SNL 2007, Section 6.3.3.2.

NOTES: [1] Forces defined in SNL 2007, Section 6.3.3.2, p. 6-109.

[2] Forces calculated by linear interpolation of data at 5 and 7 m/s. For example, for the TAD-bearing waste package with 23-mm-thick OCB (third column of table): 6,000,000 + 1/0.75*(7,800,000 – 6,000,000) = 8,400,000.

[3] The impact force at 10 m/s is the average of six impact forces corresponding to the 1/4, 1/2, and 3/4 impact points and ±6 degrees, as described in SNL 2007(second-to-last paragraph in Section 6.3.3.2). The six force values for the TAD-bearing and codisposal waste packages are defined in SNL 2007, Tables 6-13 and 6-14 and Tables 6-18 and 6-19, respectively.




Source: SNL 2007, Figures 6-32, 6-33, 6-35, and 6-36.

Figure 1. Deformed Shapes for TAD-bearing and Codisposal Waste Packages for Various Impact Velocities and the Associated Probability of Rupture When Subjected to Multiple Impacts

## 2. COMMITMENTS TO NRC

None.

## 3. DESCRIPTION OF PROPOSED LA CHANGE

None.

## 4. REFERENCES

SNL (Sandia National Laboratories) 2007. *Mechanical Assessment of Degraded Waste Packages and Drip Shields Subject to Vibratory Ground Motion.* MDL-WIS-AC-000001 REV 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070917.0006; DOC.20080623.0002; DOC.20081021.0001.

**RAI Volume 3, Chapter 2.2.1.3.2, Second Set, Number 3:**

> Explain why waste package rupture was excluded in the kinematic analyses for realizations where the computed maximum effective strain exceeded the effective strain limits and how this exclusion does not underestimate waste package damage. Provide triaxiality factors and deformation state (i.e., tension or compression) for realizations in which the maximum effective strain exceeded the effective strain criterion.
>
> Basis: The applicant defined the maximum effective strain limit for the waste package rupture condition as 0.57 for uniaxial tension and 0.285 for biaxial tension (SNL, 2007, Section 6.3.2.2.5). For realizations where the maximum effective strain is less than 0.285, rupture was not considered credible. If the maximum effective strain exceeded 0.285, the strain limit was multiplied by the triaxiality factor, resulting in an effective strain limit between 0.285 and 0.57. Subsequently, the rupture condition was evaluated based on the newly computed strain limit. For some realizations the computed maximum effective strains exceed the effective strain limit (e.g., SNL, 2007, Table 6-92), however, no waste package rupture was determined for these realizations.

## 1. RESPONSE

The potential for rupture of the waste package outer corrosion barrier is determined using a multi-step screening process illustrated in Figure 6-25 of *Mechanical Assessment of Degraded Waste Packages and Drip Shields Subject to Vibratory Ground Motion* (hereinafter referred to as the mechanical assessment; SNL 2007, Section 6.3.2.2.5). Rupture is screened out when any of the following conditions are true on both the outer and inner surfaces of all finite elements in the outer corrosion barrier.

1. The effective strain ($\varepsilon_{eff}$) is less than 0.285.
2. The sum of the principal stress components ($\sigma_1 + \sigma_2 + \sigma_3$) is less than zero.
3. For uniaxial tension ($\sigma_2 + \sigma_3 < 0$), the effective strain is less than 0.57.
4. For biaxial tension, a triaxiality (“knockdown”) factor is calculated, producing a new strain limit (between 0.285 and 0.57) and the effective strain is less than the new strain limit.

The second condition in this process is the key criterion for this discussion. The stress state is compressive when the sum of the principal stress components ($\sigma_1 + \sigma_2 + \sigma_3$) is less than zero, and tensile failure cannot occur in a compressive state, even though the effective strain may exceed the ultimate tensile strain limit. The ultimate tensile strain limit for Alloy 22 in uniaxial tension is 0.57 (SNL 2007, Section 6.2.2). By convention, a positive stress indicates tension and a negative stress indicates compression in these structural analyses.

Tables 6-60, 6-90, and 6-92 in the mechanical assessment (SNL 2007) have values for the maximum effective strain in the outer corrosion barrier that are larger than the uniaxial tensile strain limit of 0.57 for Alloy 22. However, the stress state is compressive at all times when the effective strain exceeds 0.285, so rupture does not occur because the stress state is compressive (Figures 2, 4, and 6).

This behavior is illustrated by the response of the single element represented in Table 6-92 in the mechanical assessment (SNL 2007) whose maximum effective strain is 0.594. Figure 1 presents the effective strain as a function of time for this element. Figure 1 shows that the effective strain is below 0.285 for the first 0.04 seconds, so rupture does not occur initially (per the first condition in the screening process). Figure 1 also shows that after about 0.09 seconds the effective strain is greater than 0.57 for about 0.05 seconds, so the potential for rupture from uniaxial tension must be evaluated. Figure 2 presents the time-dependent behavior of the three principal stress components for this element. Although the stress state is initially tensile, $\sigma_2$ and $\sigma_3$ become negative (compressive) after about 0.025 seconds, and $\sigma_1 + \sigma_2 + \sigma_3$ remains negative for all times after 0.025 seconds. It follows that the stress state is always compressive when the effective strain exceeds 0.57, so rupture cannot occur for this element.

Similar behavior is observed for three elements represented in Table 6-60 of the mechanical assessment (SNL 2007) whose peak maximum effective strain value is 0.671. Figure 3 shows the effective strain as a function of time for these three elements, and Figure 4 shows the three principal stresses for each of the elements as a function of time. Figure 3 shows that the effective strain is below 0.285 for the first 0.03 seconds, so rupture does not occur initially (per the first condition in the screening process). Figure 3 also shows that the effective strain peaks and plateaus at a value greater than 0.57 after 0.06 seconds, so the potential for rupture must be evaluated. Figure 4 shows that the stress state has some tensile components for the first 0.03 seconds, although the effective strain remains below 0.285 (Figure 3) so rupture does not occur per condition 1. Figure 4 also shows that $\sigma_1 + \sigma_2 + \sigma_3$ remains negative for all times after 0.03 seconds. Rupture cannot occur for these elements, even when the peak maximum effective strain exceeds 0.57 after 0.06 seconds, because the stress states are always compressive.

The peak maximum effective strain value in Table 6-90 of the mechanical assessment (SNL 2007) is 0.681, and there were three elements for which the effective strain exceeded the uniaxial strain limit. Figure 5 shows the effective strain as a function of time for these three elements, and Figure 6 shows the three principal stresses for the elements as a function of time. The behavior shown in Figures 5 and 6 is similar to the behavior shown in Figures 1 to 4. Rupture does not occur initially because the effective strain is below 0.285 (per condition 1) and rupture does not occur after 0.025 seconds because $\sigma_1 + \sigma_2 + \sigma_3$ remains negative (compressive) for all times after 0.025 seconds.

Although Tables 6-60, 6-90, and 6-92 in the mechanical assessment (SNL 2007) have values for the maximum effective strain in the outer corrosion barrier that are larger than the uniaxial tensile strain limit of 0.57, the stress state is compressive whenever this occurs, so rupture cannot occur. Therefore, exclusion of rupture for the kinematic analyses when the maximum effective strain in the outer corrosion barrier is greater than 0.57 does not underestimate waste package rupture.

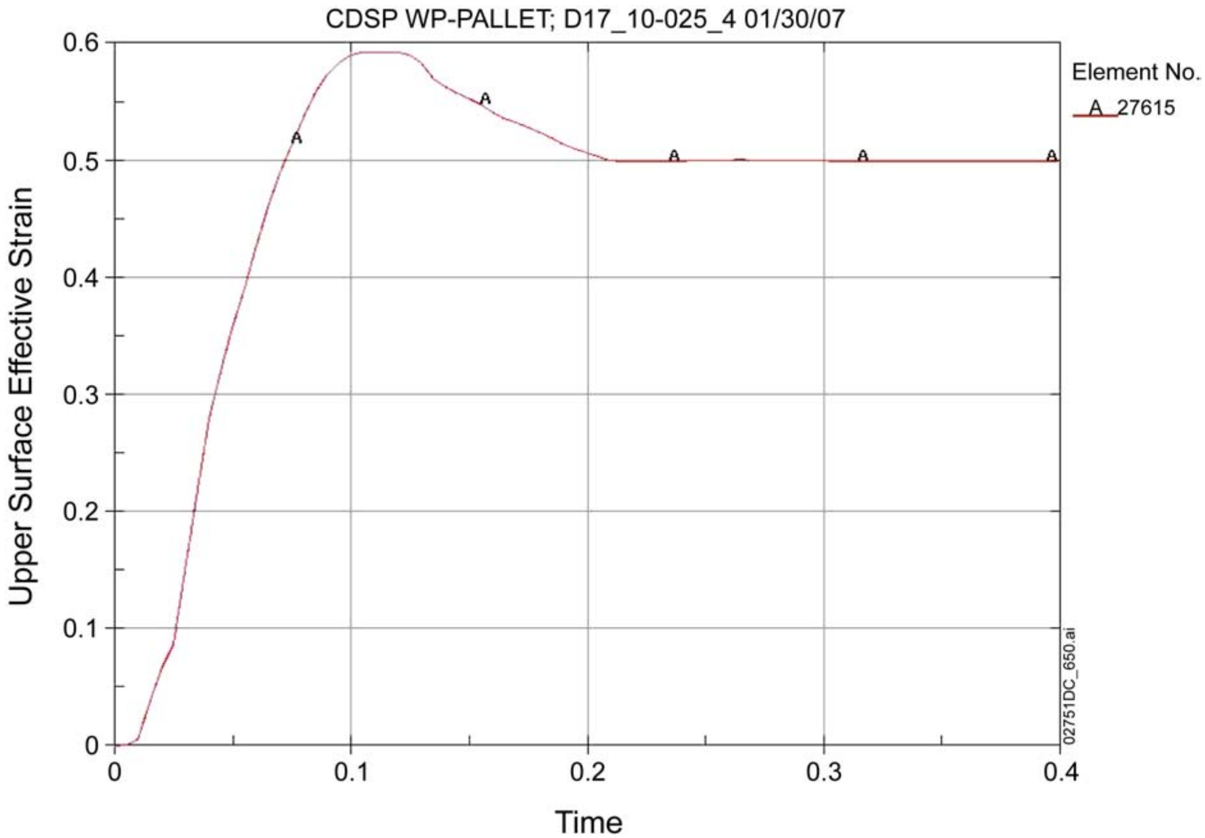



Figure 1. Effective Strain (dimensionless) as a Function of Time (seconds) for Element A27615 with Maximum Effective Strains Larger Than the Uniaxial Strain Limit of 0.57

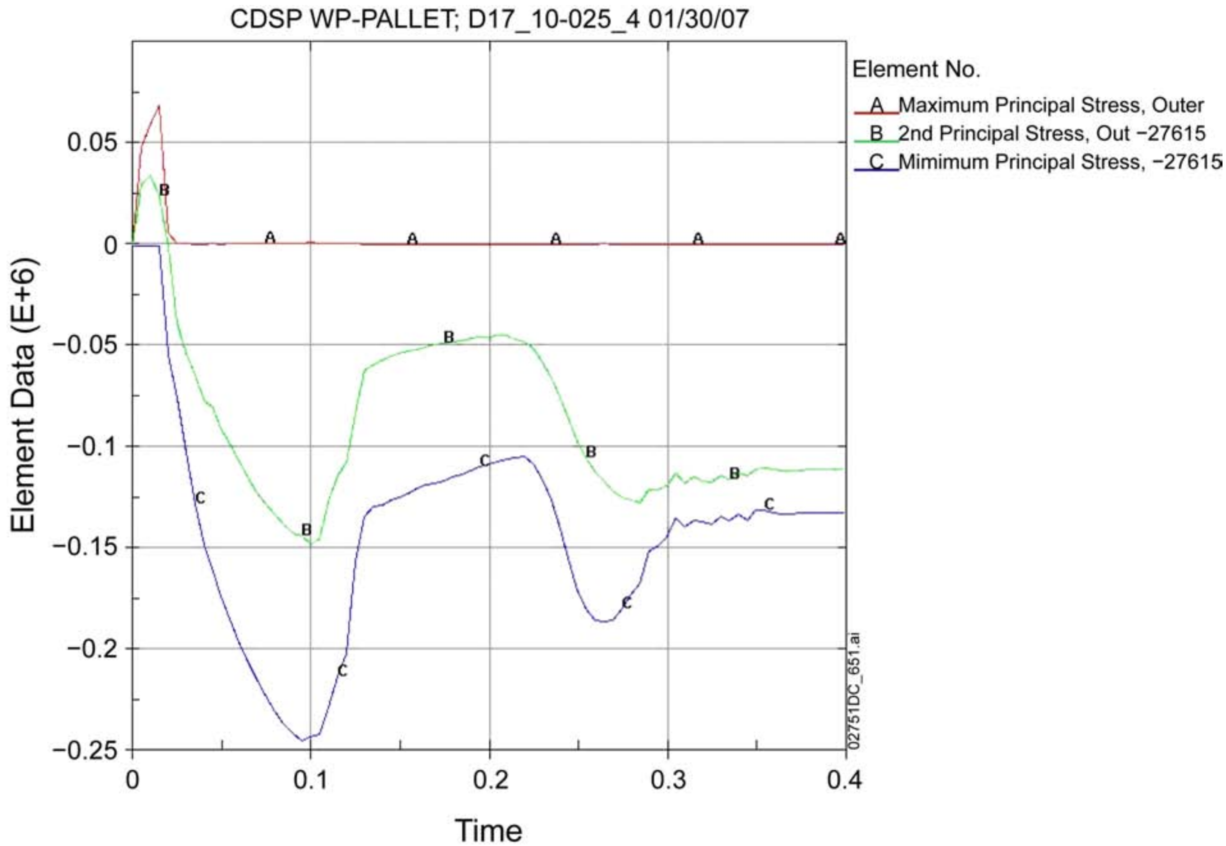



Figure 2. Principal Stresses (millions of psi) as a Function of Time (seconds) for the Element A27615 Table 6-92 (SNL 2007) with Maximum Effective Strains Larger Than the Uniaxial Strain Limit of 0.57

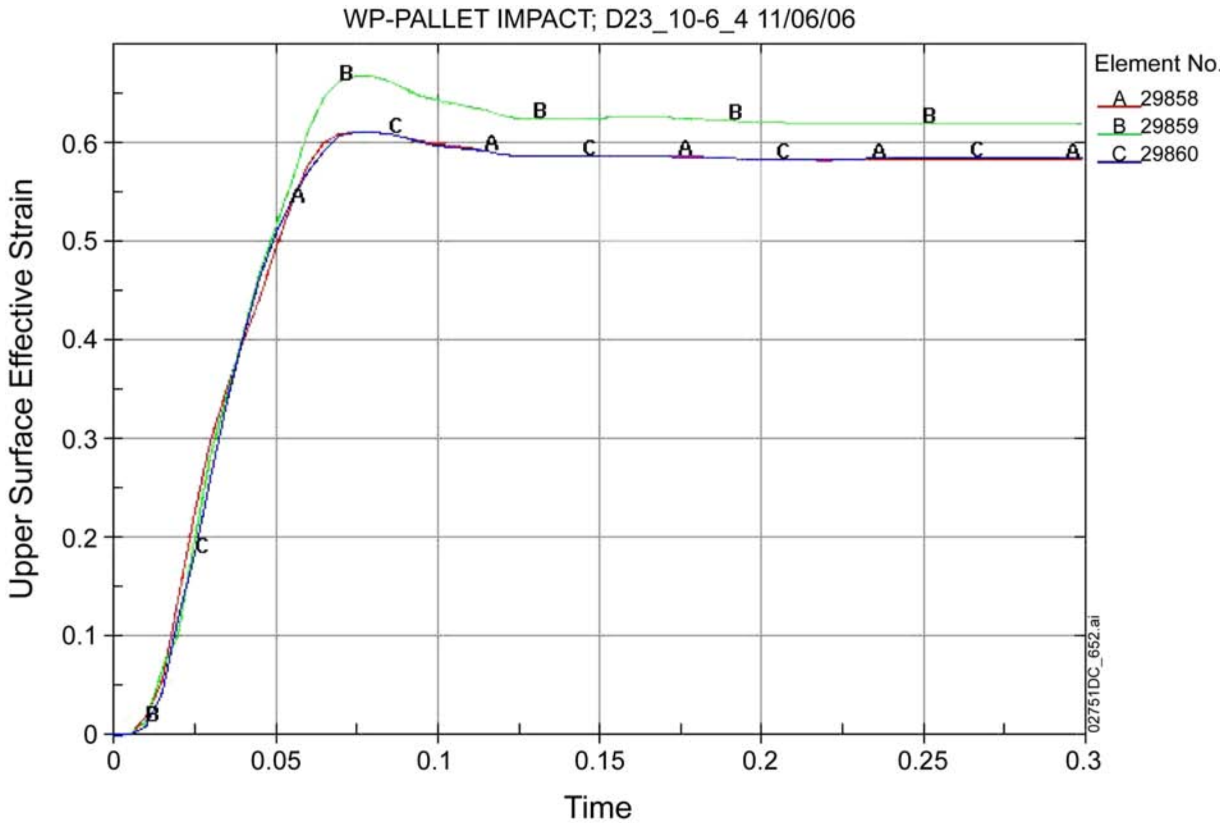



Figure 3. Effective Strain (dimensionless) as a Function of Time (seconds) for Elements with Maximum Effective Strains Larger Than the Uniaxial Strain Limit of 0.57

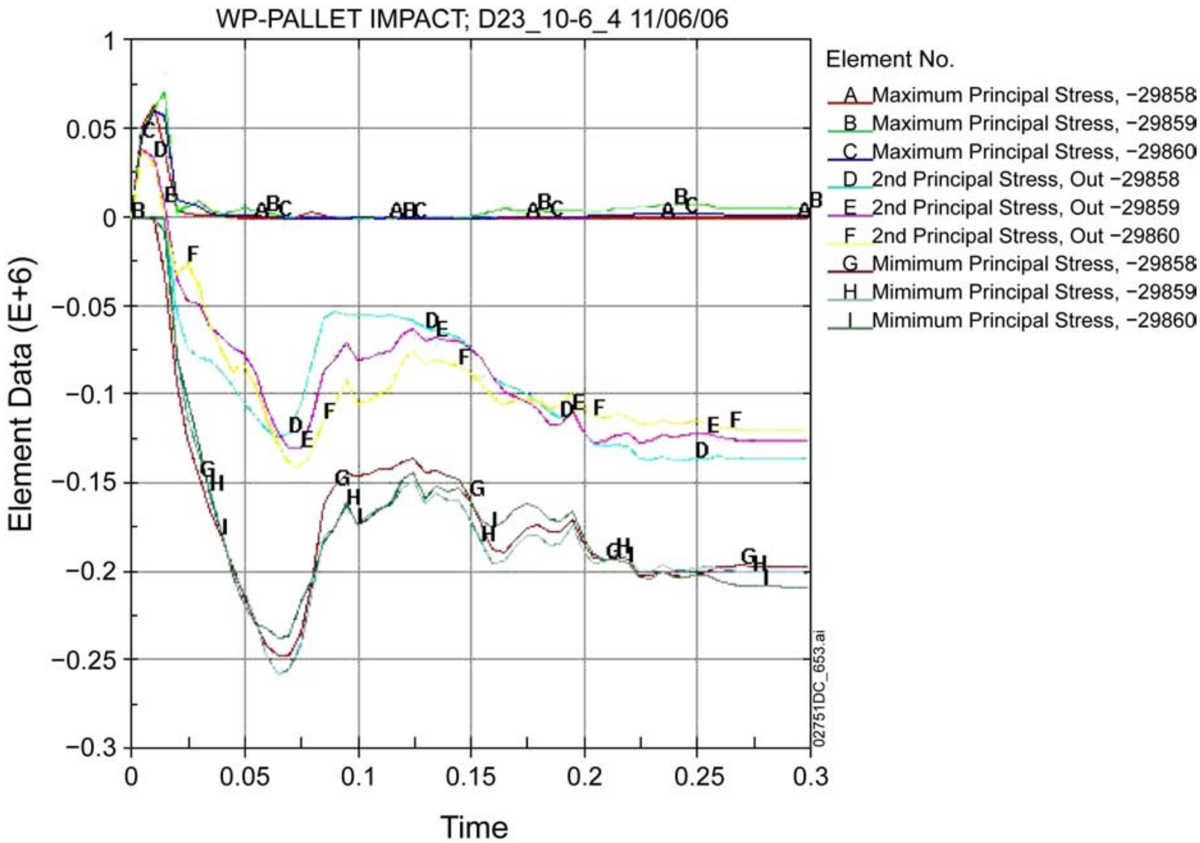



Figure 4. Principal Stresses (millions of psi) as a Function of Time (seconds) for Elements with Maximum Effective Strains Larger Than the Uniaxial Strain Limit of 0.57

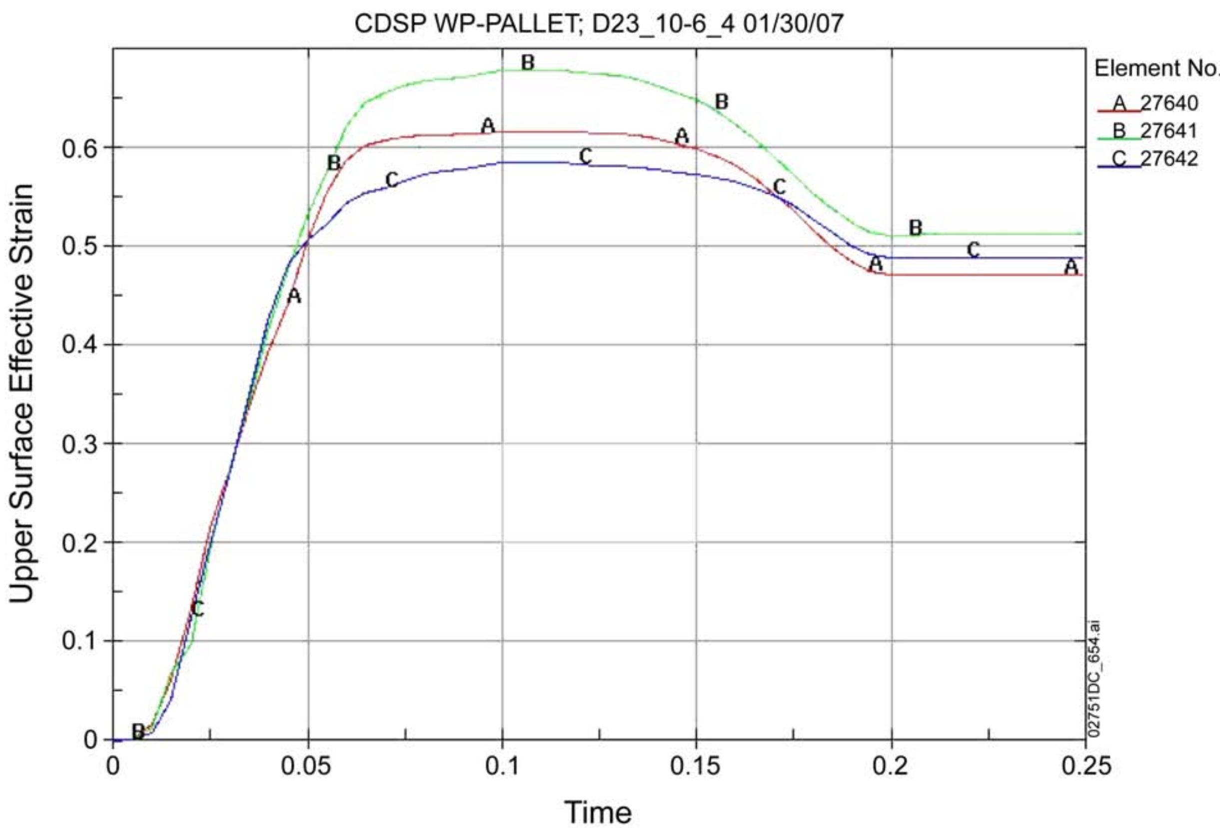



Figure 5. Effective Strain (dimensionless) as a Function of Time (seconds) for Elements with Maximum Effective Strains Larger Than the Uniaxial Strain Limit of 0.57

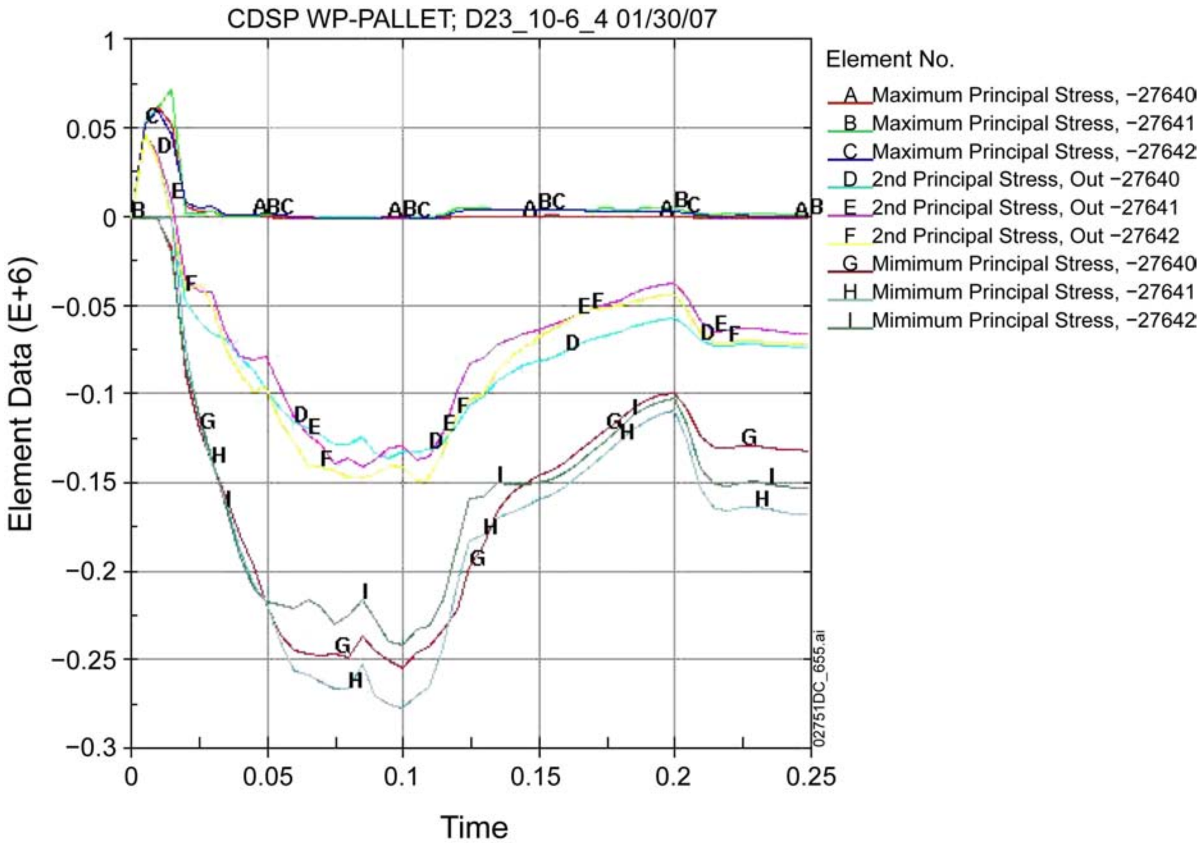



Figure 6. Principal Stresses (millions of psi) as a Function of Time (seconds) for Elements with Maximum Effective Strains Larger Than the Uniaxial Strain Limit of 0.57

## 2. COMMITMENTS TO NRC

None.

## 3. DESCRIPTION OF PROPOSED LA CHANGE

None.

## 4. REFERENCES

SNL (Sandia National Laboratories) 2007. *Mechanical Assessment of Degraded Waste Packages and Drip Shields Subject to Vibratory Ground Motion.* MDL-WIS-AC-000001 REV 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070917.0006; DOC.20080623.0002; DOC.20081021.0001.

**RAI Volume 3, Chapter 2.2.1.3.2, Second Set, Number 8:**

> Clarify apparent inconsistencies in the information reported in the SAR Section 2.3.4.5.4.3.1.2 and the SAR Figure 2.3.4-89 regarding waste package damage area as a function of yield stress.
>
> Basis: In SAR Section 2.3.4.5.4.3.1.2 the applicant stated that for a residual stress threshold of 90 percent of the yield stress, the damage area resulted in 0.2 percent of the total waste package outer corrosion barrier surface area and a residual stress threshold of 105 percent of the yield stress resulted in a 3 percent damage area. In contrast, SAR Figure 2.3.4-89 shows a damage area of 3 percent corresponds to a residual stress threshold of 90 percent of the yield stress, whereas a reported damaged area of 0.2 percent corresponds to a residual stress threshold of 105 percent of the yield stress.

## 1. RESPONSE

The DOE agrees that the percentages cited in the fourth and fifth sentences in SAR Section 2.3.4.5.4.3.1.2 are inconsistent with SAR Figure 2.3.4-89. The DOE will correct the numerical values in the fourth and fifth sentences of SAR Section 2.3.4.5.4.3.1.2 to read as follows:

> If the residual stress threshold is 90% of the yield strength, the average damaged area is less than 1.2% of the total outer corrosion barrier surface area. If the RST is 105% of the yield strength, the averaged damaged area is less than 0.1% of the surface area.

These numerical values are consistent with SAR Figure 2.3.4-89 and with the data in *Mechanical Assessment of Degraded Waste Packages and Drip Shields Subject to Vibratory Ground Motion* (SNL 2007, Table 6-163).

## 2. COMMITMENTS TO NRC

The DOE commits to update the LA as stated in Section 3. The changes to the LA will be included in the future LA update.

## 3. DESCRIPTION OF PROPOSED LA CHANGE

The DOE will correct the numerical values in the fourth and fifth sentences of SAR Section 2.3.4.5.4.3.1.2 to read as follows:

> If the residual stress threshold is 90% of the yield strength, the average damaged area is less than 1.2% of the total outer corrosion barrier surface area. If the RST is 105% of the yield strength, the averaged damaged area is less than 0.1% of the surface area.

## 4. REFERENCES

SNL (Sandia National Laboratories) 2007. *Mechanical Assessment of Degraded Waste Packages and Drip Shields Subject to Vibratory Ground Motion.* MDL-WIS-AC-000001 REV 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070917.0006; DOC.20080623.0002; DOC.20081021.0001.